

Example 3c: User-Defined Doubly Periodic Architecture

This example problem illustrates how users may input their own repeating unit cell architecture through the MAC/GMC 4.0 input file. In particular, a B/Al composite with randomly distributed fibers (see [Figure 3.6](#)) subjected to an applied strain at a (fast) rate of 0.1/s is considered. For more information on the user-defined repeating unit cell architecture, see the MAC/GMC 4.0 Keywords Manual Section 3.

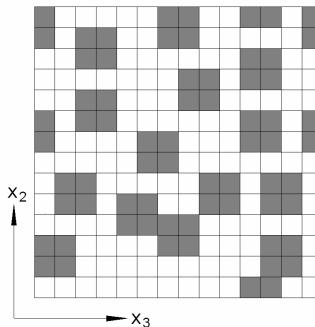


Figure 3.6 Example 3c: Random fiber composite architecture specified through the input file.

MAC/GMC Input File: `example_3c.mac`

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MAC/GMC 4.0 Example 3c - Random composite architecture using 2-D GMC
*CONSTITUENTS
  NMATS=2
    M=1 CMOD=6 TREF=21. MATID=A
    M=2 CMOD=1 TREF=21. MATID=C
*RUC
  MOD=2 ARCHID=99
  NB=14 NG=14
  H=1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1.
  L=1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1.
  SM=1,2,2,2,2,1,1,2,2,1,1,2,1
  SM=1,2,1,1,2,2,1,1,2,2,2,2,1
  SM=2,2,1,1,2,2,2,2,2,2,1,1,2,2
  SM=2,2,2,2,2,2,2,1,1,2,1,1,2,2
  SM=2,2,1,1,2,2,2,1,1,2,2,2,2,2
  SM=1,2,1,1,2,2,2,2,2,1,1,2,1
  SM=1,2,2,2,2,1,1,2,2,2,1,1,2,1
  SM=2,2,2,2,2,1,1,2,2,2,2,2,2
  SM=2,1,1,2,2,2,2,1,1,2,1,1,2
  SM=2,1,1,2,1,1,2,2,1,1,2,1,1,2
  SM=2,2,2,2,1,1,1,2,2,2,2,2,2
  SM=1,1,2,2,2,2,1,1,2,2,2,1,1,2
  SM=1,1,2,2,2,2,2,2,2,2,1,1,2
  SM=2,2,2,2,2,2,2,1,1,2,2,2,2,2
*MECH
  LOP=2
  NPT=2 TI=0.,0.1 MAG=0.,0.01 MODE=1
*SOLVER
  METHOD=1 NPT=2 TI=0.,0.1 STP=0.00005

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*PRINT
  NPL=6
*XYPLOT
  FREQ=1
  MACRO=1
  NAME=example_3c X=2 Y=8
  MICRO=0
*END

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Annotated Input Data

1) Flags: None

2) Constituent materials (***CONSTITUENTS**) [KM_2]:

Number of materials:	2	(NMATS=2)
Materials:	Boron fiber	(MATID=A)
	Aluminum (6061-0a)	(MATID=C)
Constitutive models:	Boron fiber: linearly elastic	(CMOD=6)
	Al matrix: Bodner-Partom	(CMOD=1)
Reference Temperature:	21. °C	(TREF=21)

3) Analysis type (***RUC**) → Repeating Unit Cell Analysis [KM_3]:

Analysis model:	Doubly periodic GMC	(MOD=2)
Architecture:	User-defined	(ARCHID=99)
No. subcells in x ₂ -dir.:	14	(NB=14)
No. subcells in x ₃ -dir.:	14	(NG=14)
Subcell heights:	1.	(H=1., 1., ...)
Subcell lengths:	1.	(L=1., 1., ...)
Material assignment:	see input file	(SM=...)

The materials that occupy each subcell are specified with SM=.... Each separate SM=... line corresponds to a different descending value of β , while the comma separated material numbers on a given line correspond to different ascending γ values. For more information on the user-defined repeating unit cell architecture, see the MAC/GMC 4.0 Keywords Manual Section 3.

4) Loading:

a) Mechanical (***MECH**) [KM_4]:

Loading option:	1	(LOP=1)
Number of points:	2	(NPT=2)
Time points:	0., 0.1 sec.	(TI=0., 0.1)
Load magnitude:	0., 0.01	(MAG=0., 0.01)
Loading mode:	strain control	(MODE=1)

b) Thermal (***THERM**): None

c) Time integration (***SOLVER**) [KM_4]:

Time integration method:	Forward Euler	(METHOD=1)
Number of points:	2	(NPT=2)

Time points:	0., 0.1 sec.	(TI=0., 0.1)
Time step sizes:	0.00005 sec.	(STP= 0.00005)

5) Damage and Failure: None

6) Output:

a) Output file print level (*PRINT) [KM_6]:

Print level:	6	(NPL=6)
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b) x-y plots (*XYPLOT) [KM_6]:

Frequency:	1	(FREQ=1)
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Number of macro plots:	1	(MACRO=1)
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Macro plot names:	example_3c	(NAME=example_3c)
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Macro plot x-y quantities:	$\epsilon_{22}, \sigma_{22}$	(X=2 Y=8)
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Number of micro plots:	0	(MICRO=0)
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7) End of file keyword: (*END)

Results

The results for this example problem are plotted in [Figure 3.7](#). For this composite with randomly distributed strongly bonded fibers, GMC works well. Note, however, that in the presence of a weak interface or fiber-matrix debonding, however, the lack of normal-shear field coupling in GMC would result in significant inaccuracies in the predicted transverse composite response. Such a composite could be modeled more accurately using the high-fidelity GMC (HFGMC) model, which does include the normal-shear field coupling. Example Problem 3f illustrates the use of HFGMC within MAC/GMC 4.0.

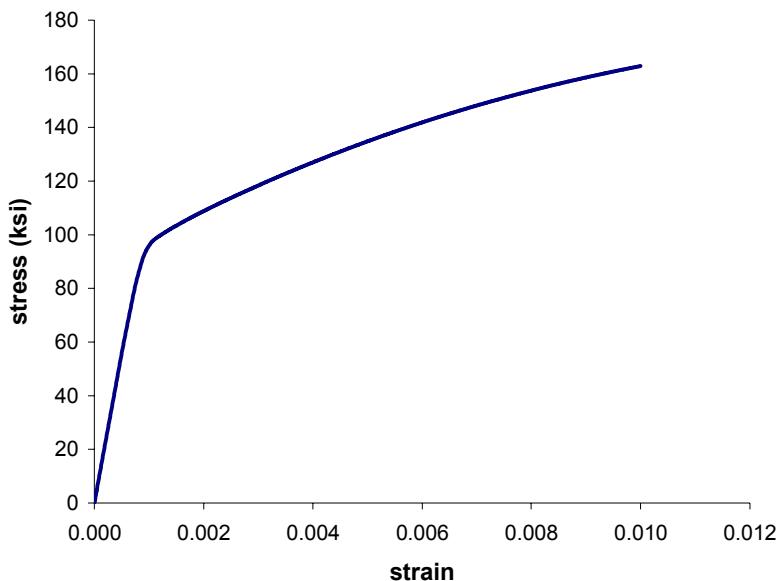


Figure 3.7 Example 3c: plot of the simulated transverse stress-strain ($\sigma_{22}-\epsilon_{22}$) response for a 0.3469 fiber volume fraction B/Al composite at 21 °C as represented by a user-defined repeating unit cell architecture intended to simulate randomly distributed fibers.